Supporting Information

Micropatterning of Multiple Photonic Colloidal Crystal Gels for Flexible Structural Color Films

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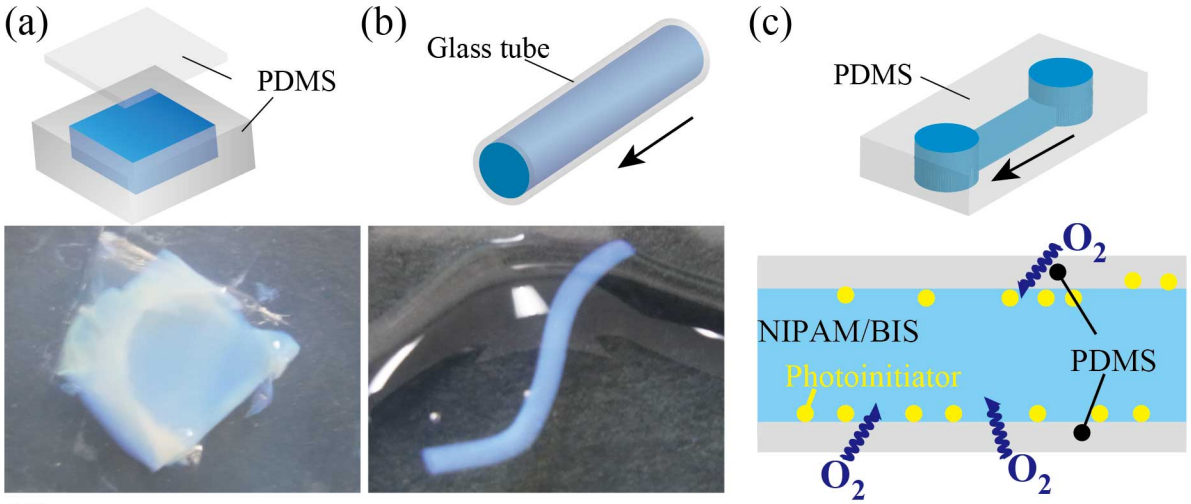
Supporting Information SI1: Gelation of hydrogels in the microchannel

The desalted colloidal precursor was initially prepared by mixing an aqueous solution of the NIPAM monomer (1 M), the BIS (0.1 M) and the IRGACURE photoinitiator with a desalted monodisperse silica colloidal suspension (particle diameter: 110nm). The mixed suspension was then desalted using an ion-exchange resin. Subsequently, the resulting precursor was injected into a glass tube (100 μm in diameter), a PDMS hole, and a PDMS microchannel (width: 400 μm, height: 100 μm) and exposed to UV light for 1.5 min. Polymerization of NIPAM was successful both in the glass tube and in the PDMS hole, however, gelation was not observed in the PDMS microchannel. We expect that this was due to the passage of oxygen (which inhibits NIPAM gelation) through the microchannel walls, thus resulting in absorption of the photoinitiator onto the PDMS. Polymerization of NIPAM in the PDMS microchannel was therefore achieved following by degassing of the microchannel and the photoinitiator (IRGACURE, 2 vol%).



(d)

Material of container	Treatment	Gelation
on PDMS hole (0.1 cm^3)	–	△ only center
in Glass tube	–	✓
in PDMS microchannel (thickness = 100 μm)	–	✗
	Deaerate in water	✗
	Deaerate in IRGACURE 2%	✓

Figure SI1. (a, b) The cured PCCGs in (a) a PDMS chamber and (b) a glass tube. (c) Setup employed for the gelation of PCCGs in the microchannels. (d) Results of the gelation studies.

Supporting Information SI2: Angle dependency measurement of PCCGs

To check the angle dependency of our PCCGs (silica particle diameter: 110 nm, particle concentration: 0.24 g/mL), we observed PCCG, which were polymerized on a glass substrate, with a digital microscope (Keyence, VH-Z20R). The illumination angle, θ, and the observation angle were the same for the experiment. Figure SI2 shows the obtained images of the PCCGs at 90, 60, 45 and 30. These results indicate that the angle dependency of the PCCGs was low.

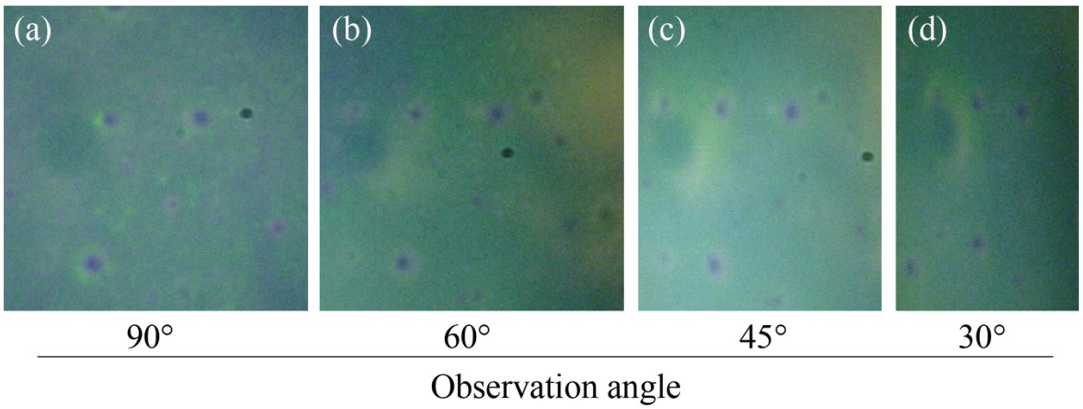
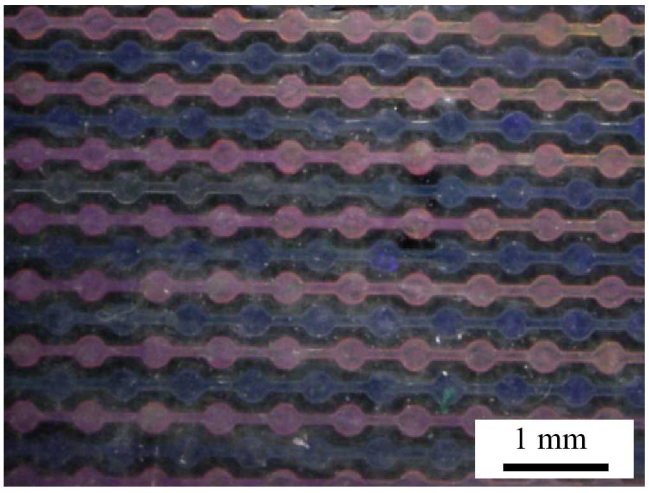


Figure SI2. Obtained images of the PCCGs at various observation angles.

Supporting Information SI3: Patterning of the PEG PCCGs

We initially prepared two precursors composed of PEG and a silica colloidal suspension, where the concentration of 180 nm silica particles was 0.36 mg/mL and the concentration of the 110 nm silica particles was 0.24 mg/mL. In both precursor, a PEG concentration of 25 wt% was employed. After addition of the IRGACURE photoinitiator to the different precursors, they were successfully patterned in the microchannel (Figure SI3). This result indicated that our micropatterning method can be employed for various types of photocurable resins.

(a)



(b)

Concentration (mg/mL)		0.36	0.30	0.24	0.16	0.12	0.08
Peak wavelength (nm)	φ110 nm	UV	414	449	456	508	N. A.
	φ180 nm	662	691	IR	IR	IR	IR

Figure SI3. (a) The two patterned types of PEG-based PCCGs in the microchannel. (b) Table summarizing the peak reflective wavelengths observed under each condition.

Supporting Information SI4: Design of the microchannels

The microchannels employed herein have parallel flow paths and pixels of various shapes, and so the shapes of the patterned PCCGs can be tuned based on the shapes of the microchannels. Thus, to pattern various shapes of microchannels, we designed a pattern with a dense arrangement of pixels. More specifically, the circular diameters and the diagonal lengths of the polygons were designed to be three times the width of the channels, w. When the distance between neighboring pixels and channels was 0.5w, a dense arrangement of pixels was achieved, as shown in Figure SI4. More specially, this figure shows a unit area of each pixel, and a pattern is formed by arranging the unit areas continuously. The ratios of the patterning areas within the unit areas were calculated as 61.0, 66.6, and 78.9, for the circular-, quadrangular-, and hexagonal- shaped pixels, respectively.

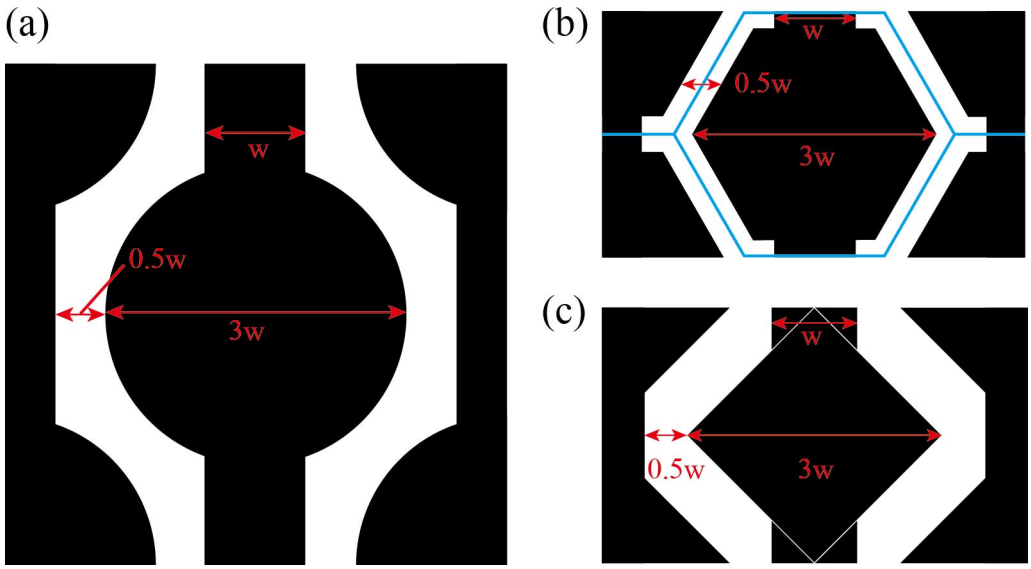


Figure SI4. Enlarged representations of the patterning areas of PCCGs in the microchannels for (a) circular, (b) hexagonal, and (c) quadrangular, pixel shapes.